too small to be appreciable, to one of a degree of arc or even more. . . . It also varies somewhat with the angle of elevation." In one of his examples he supposed the jump to be 22 to 23 minutes. Although the jump and vertical drift are uncertain in amount, they have considerable influence on the range and time of flight, and on this account the calculation of trajectories is a decidedly unsatisfactory method of testing the coefficients of resistance of the air to elongated projectiles.

In the early days of elongated projectiles the vertical drift caused by the "kite-like action" of the shot was duly recognized, but of late this disturbing force has been commonly ignored. For now, when a calculated range is shorter than the experimental range, it is at once assumed that the theoretical resistance is too high. This resistance is forthwith reduced so as to make the calculated agree with the experimental ranges, but seldom is any care taken to compare the time of flight calculated with this reduced resistance with the experimental time. It ought, however, to be remembered that, while a reduction of resistance *increases* the range it *diminishes* the time of flight over a given range. Major Ingalls has given a complete example of this method of correcting my resistance (Problems, &c., p. 151). For elevations of

2°, 4°, 6°, 8°, and 10°,

he found it necessary to reduce my coefficients by

4·5 2·3 5·2 8·1 9.7 per cent.,

in order to obtain the experimental ranges by calculation; and these *reduced* resistances gave the calculated times of flight *too short* by

0″·09 0″·12 0″·13 0″·26 and 0″·42,

which proves clearly that the theoretical resistances had been too much reduced throughout. Also, if the method of correction pursued in the above example was correct, it would follow that the coefficient of resistance is a function of the elevation, which is simply absurd.

On the other hand, suppose we correct the elevation so as to make the calculated agree with the experimental range, which seems to me to be a satisfactory *approximate* correction in such cases. A careful calculation of the trajectory of an ogival-headed shot (two diameters) fired from the 4-inch B.L. gun, at an elevation of 15°, gave a range of 6448 yards (185 yards too short by the range table), and time of flight 20″·46 (1″·10 too short), the density of the air having been supposed to vary with the height of the shot. Now, corresponding to an elevation of 14° 16′, the range table gives a range of 6448 yards, and time of flight 20″·53. If we suppose that the elevation of the gun, 14° 16′, was practically increased by 44′ by jump and vertical drift, we obtain an elevation of 15° for the initial direction of the shot. But, according to calculation, for an elevation of 15° we have found the range 6448 yards exactly, and the time of flight 20″·46, which is only − 0″·07 in error, and the calculated horizontal striking velocity is 646 f.s. This, I maintain, is the proper method of correction, because it corrects both *range* and *time* of flight, when there is no wind. Using the general tables and the horizontal muzzle velocity, the calculated time over 6448 yards is found to be 20″·53, and horizontal striking velocity 647 f.s., where $\tau$ = 0·967, the mean density of the air, as the projectile would rise to a height of 1800 feet.

If the above be a correct view of what takes place, it follows that the axis of the shot during its flight is inclined at such a small angle to the direction of its motion, that the resistance of the air to its forward motion is not sensibly greater than when it moves in the direction of its axis. But small as this angle must be, we find evidence of the marked effect of the lateral action of the air in causing the shot to drift to the right towards the end of the range. It is therefore to be expected that the resistance of the air, acting from below on the shot, soon after it leaves the gun will raise the shot upwards, and cause it to move as if it had been fired at an elevation a little greater than that at which the gun was laid.

The Ordnance Committee fired some ogival-headed projectiles from a 9·2-inch wire gun at high elevations in 1888, professedly to try whether calculations of trajectories at very long ranges are trustworthy. But before experimenting they invited calculators to furnish them with the calculated range and time of flight of a 380-pound elongated shot fired at an elevation of 40° with a muzzle velocity of 2360 f.s. My calculations for an ogival head, struck with a radius of one diameter and a half, gave a range of 19,436 yards, and time of flight 62″·15, which were sent in in March 1888. Allowing 300 yards for jump and vertical drift, I obtained a range of 19,736 yards. In April two rounds were fired with a velocity of 2375 f.s. at an elevation of 40°, which gave ranges of 21,048 and 21,358 yards. My reply to this announcement, by return of post, was that the ranges were about 1500 yards too great. In July the experiment was repeated, which gave ranges of 20,236 and 20,210 yards, being a reduction of near 1000 yards. Two rounds fired at an elevation of 30° gave ranges of 17,500 and 18,344 yards; two at 35° gave ranges of 19,420 and 18,963 yards; and one at 45° gave a range of 21,800 yards. The times of flight have not been published. These great variations in range were due in part to unsteadiness in the motion of the shot, but chiefly to the prevalence of high favourable winds.

In order to test guns or coefficients of resistance in a satisfactory manner, *calm weather* is absolutely necessary. And if the shot is expected to rise to a height of two or three miles, trial balloons ought to be sent up to test the state of the currents in the higher regions. Afterwards, when good mean results of experiments have been obtained, then, and not till then, may these mean results be used to test the results of calculation. Experiments ought not to be made at all unless precautions necessary to secure a correct result can be taken.

I have calculated a complete range table for the 9·2-inch gun for elevations 1° to 45°, according to the original programme of the Ordnance Committee (NATURE, September 13, 1888, p. 468), where the net results of calculation have been given. These ranges will require an addition perhaps of about 2 per cent. for jump, vertical drift, &c., and a further 1 per cent. if the ogival head be struck with a radius of two diameters instead of one and a half, and the increment of time must be ruled by this increment of range.

My sole object having been to obtain the correct law of resistance of the air to the motion of projectiles, I was always ready to consider any proposed correction. But my results, obtained from numerous and most exact experiments, could be changed only on perfectly satisfactory evidence. That evidence I have failed to obtain in any single case, so that my results remain practically the same as they were given in my original reports, 1868–80. I have recently published a revised account of all my experiments, accompanied by newly calculated general tables, for both English and French measures, and other tables required in the calculation of trajectories, according to the results of modern analysis. With these helps I have now thoroughly tested my final results by the use of range tables of the 4-inch, 6·3-inch, and 12-inch guns, with the most gratifying results. And Major McClintock, R.A., has tested my coefficients for small-arm bullets, with very satisfactory results (Proc. R.A. Inst., xii. 569). This evidence of the accuracy of my results is the more valuable because it is derived from Government experiments, made for other purposes, which have manifestly been carried out with great care and ability. Anyone so disposed has the means to re-examine the whole matter for himself. If there be not some error in my calculations, it appears that my results do not admit of any real improvement, and consequently my labours in this matter may be considered to have reached a satisfactory conclusion.

F. BASHFORTH.

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## *FORTHCOMING SCIENTIFIC BOOKS.*

THE following is a list of scientific works which will be issued by various publishers in the course of the spring:—

Messrs. Macmillan and Co.:—"Essays on some Controverted Questions," with a Prologue, by Prof. Huxley; "The Beauties of Nature," by Sir John Lubbock, F.R.S., illustrated; "Island Life; or, The Phenomena and Causes of Insular Faunas and Floras," including a revision and attempted solution of the problem of geological climates, by A. R. Wallace, with illustrations and maps, new and cheaper edition; "The Apodidæ," a morphological study, by Henry M. Bernard, illustrated (Nature Series); "Experimental Evolution," by Henry de Varigny; "The Diseases of Modern Life," by B. W. Richardson, F.R.S., new and cheaper edition; "The Geography of the British Colonies"—"Canada," by George M. Dawson, "Australia and New Zealand," by Alexander Sutherland (Macmillan's Geographical Series); "Scientific Papers," by Oliver Heaviside; "The Algebra of Co-Planar Vectors and Trigonometry," by R. B. Hayward, F.R.S., Assistant Master at Harrow; "Key and Students'

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Companion to Higher Arithmetic and Elementary Mensuration," by P. Goyen, Inspector of Schools, Dunedin, New Zealand; "Arithmetic for Schools," by Barnard Smith, late Fellow and Bursar of St. Peter's College, Cambridge; carefully revised in accordance with modern methods by W. H. H. Hudson, Professor of Mathematics, King's College, London; "Blowpipe Analysis," by J. Landauer, authorized English edition by J. Taylor and W. E. Kay, of the Owens College, Manchester, new edition, thoroughly revised with the assistance of Prof. Landauer; "Nature's Story Books," I. "Sunshine," by Amy Johnson, illustrated.

The Clarendon Press:—"Mathematical Papers of the late Henry J. S. Smith, Savilian Professor of Geometry in the University of Oxford," with portrait and memoir, two vols.; "Plane Trigonometry without Imaginaries," by R. C. J. Nixon; "A Treatise on Electricity and Magnetism," by J. Clerk Maxwell, new edition; "A Manual of Crystallography," by M. H. N. Story-Maskelyne; "Elementary Mechanics," by A. L. Selby; "Weismann's Lectures on Heredity," Vol. II., edited by E. B. Poulton, F.R.S.; "Epidemic Influenza," by F. A. Dixey.

The Cambridge University Press:—"A Treatise on the Mathematical Theory of Electricity," by A. E. H. Love, Fellow of St. John's College, Cambridge, two vols., Vol. I. in the press; "The Origin of Metallic Currency and Weight Standards," by W. Ridgeway, Professor of Greek, Queen's College, Cork, and late Fellow of Gonville and Caius College; "Solutions of the Examples in 'A Treatise on Elementary Dynamics,'" by S. L. Loney, formerly Fellow of Sidney Sussex College, Cambridge.

Messrs. Longmans and Co.:—"Darwin and after Darwin: an Exposition of the Darwinian Theory, and a Discussion of Post-Darwinian Questions," by George John Romanes, F.R.S., two vols.

Messrs. A. and C. Black:—"Life in Motion; or, Muscle and Nerve," a series of lectures delivered at the Royal Institution, Christmas, 1891, by John Gray McKendrick, F.R.S., illustrated.

Messrs. J. and A. Churchill:—"A Treatise on Hygiene, edited by Thomas Stephenson and Shirley F. Murphy, in two vols., with numerous illustrations, Vol. I. nearly ready; "Chemical Technology; or, Chemistry in its Applications to Arts and Manufactures," edited by Charles E. Groves, F.R.S., and William Thorp (with which is incorporated "Richardson and Watts' Chemical Technology"), Vol. II. "Lighting: Fats and Oils, Candles, Stearine, Gas, Electric Lighting"; "Materia Medica, Pharmacy, Pharmacology, and Therapeutics," by W. Hale White; "The Student's Guide to Diseases of the Nervous System," by J. A. Ormerod, with 66 illustrations; "A Dictionary of Psychological Medicine, giving the Definition, Etymology, and Synonyms of the Terms used in Medical Psychology, with the Symptoms, Pathology, and Treatment of the Recognized Forms of Mental Disorder, together with the Law of Lunacy in Great Britain and Ireland," in two vols., edited by D. Hack Tuke.

Messrs. Whittaker and Co.:—New volumes of the Specialists' Series—"Lightning Conductors and Guards," by Oliver J. Lodge, F.R.S., with numerous illustrations; "The Dynamo," by C. C. Hawkins and F. Wallis, with numerous original diagrams; "A Guide to Electric Lighting," by S. R. Bottone, for householders and amateurs, with 77 illustrations. Whittaker's Manual Instruction Series—"Manual Instruction: Woodwork," by S. Barter, Organizer and Instructor for the London School Board, and to the Joint Committee on Manual Training of the School Board for London, the City and Guilds of London Institute, and the Worshipful Company of Drapers, with over 300 illustrations; "Leather Work, Stamped, Moulded, and Cut, Cuir-Bouillé, Sewn, &c.," by Charles G. Leland, author of "Wood Carving," with numerous illustrations. Whittaker's Library of Popular Science—"Mineralogy," by Dr. F. Hatch, with numerous illustrations; "Chemistry," by T. Bolas, with many illustrations.

Messrs. Sampson Low and Co.:—"Answers to the Questions on Elementary Chemistry, Theoretical and Practical (Ordinary Course), set at the Examinations of the Science and Art Department, South Kensington, 1887 to 1891," by John Mills, two vols., fully illustrated; "Chemistry for Students, consisting of a Series of Lessons based on the Syllabus of the Science and Art Department, and specially designed to facilitate the experimental teaching of Elementary Chemistry in Schools and Evening Classes," by John Mills, numerous illustrations; "Decorative Electricity," by Mrs. J. E. H. Gordon, with a chapter on Fire Risks by J. E. H. Gordon, and numerous illustrations by Herbert Fell, engraved on wood by J. D. Cooper; "Examination of Soils," by W. T. Brannt.

Messrs. George Philip and Son:—"Makers of Modern Thought; or, Five Hundred Years' Struggle (A.D. 1200 to A.D. 1699) between Science, Ignorance, and Superstition," by David Nasmith, in two volumes; "Christopher Columbus," by Clements R. Markham, Vol. VII. of "The World's Great Explorers and Explorations"; "The Development of Africa," by Arthur Silva White, new and cheap edition, revised to date, with fourteen coloured maps; "Philips' General Atlas," entirely new and revised edition, with several additional maps; "Philips' Systematic Atlas," for higher schools and general use, a series of physical and political maps of all the countries of the world, with diagrams and illustrations of astronomy and physical geography, specially drawn by E. G. Ravenstein; "Philips' Atlas of Astronomy," a series of seventy-two plates, with notes and index by Sir Robert Stawell Ball, F.R.S., Royal Astronomer of Ireland; "Tourists' Handy Volume Atlas of Europe," a series of coloured maps, with notes, plans of cities, and complete consulting index, by J. G. Bartholomew.

Messrs. Swan Sonnenschein and Co.:—"Animal Colouration," by Frank Beddard, Prosector to the Zoological Society, with four coloured plates by P. J. Smit, and numerous woodcuts; "Text-book of Embryology: Man and Mammals," by Dr. Oscar Hertwig, of the University of Berlin, translated and edited from the third German edition by Dr. E. L. Mark, Professor of Anatomy in Harvard University, fully illustrated; "Text-book of Embryology: Invertebrates," by Drs. Korschelt and Heider, of the University of Berlin, translated and edited by Dr. E. L. Mark, Professor of Anatomy in Harvard University, and Dr. W. M. Woodworth, Assistant Professor in Harvard University, fully illustrated; "Text-book of Geology," adapted from the work of Dr. Kayser, Professor in the University of Marburg, by Philip Lake, of St. John's College, Cambridge, fully illustrated; "The Geographical Distribution of Disease in England and Wales," by Alfred Haviland, with several coloured maps; "A Treatise on Public Hygiene and its Applications in different European Countries," by Dr. Albert Palmerg, translated, and the English portion edited and revised, by Arthur Newsholme, fully illustrated; "The Photographer's Pocket-book," by Dr. E. Vogel. "Introductory Science Text-Books," additions—introductions to the study of "Zoology," by B. Lindsay, illustrated; "The Amphioxus," by Dr. B. Hatschek, of the University of Vienna, and James Tuckey, of the University of Durham, illustrated; "Geology," by Edward B. Aveling, Fellow of University College, London, illustrated; "Physiological Psychology," by Dr. Th. Ziehen, of the University of Jena, adapted by Dr. Otto Beyer, with twenty-two figures.

Messrs. Crosby Lockwood and Son:—"A Hand-book of Brewing, a Practical Treatise for the use of Brewers and their Pupils," by Herbert Edwards Wright; "A Treatise on Earthy and other Minerals and Mining," by the late D. C. Davies, third edition, revised and very considerably extended by his son, E. H. Davies; "Fuels: Solid, Liquid, and Gaseous, their Analysis and Valuation," for the use of chemists and engineers, by H. J. Phillips, second edition, revised and much enlarged.

## *SCIENTIFIC SERIALS.*

THE most important article in the numbers of the *Journal of Botany* for January and February is one by the late Dr. A. Barclay on rust and mildews in India. He shows that the years in which the grain-crops were deficient have been those in which the climatal conditions were favourable to the growth of parasitic fungi. The chief enemy to wheat in India is *Puccinia rubigo-vera*; and it is an interesting fact that while the æcidio-form of this Uredine occurs in Europe on Borraginaceous plants, no æcidium is known in India on any species of the order. Dr. Barclay believes that its life-history has a different course in India from that taken in Europe.—Mr. W. G. Smith reports the progress at present made in the commission which he has received from the Trustees of the British Museum to make a series of water-colour drawings of the whole of the British *Basidiomycetes* for the public gallery of the Department of Botany.—A series of papers is commenced in these numbers on the first records of British flowering plants, by Mr. W. A. Clarke.

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